

Annual Dispersal Cycle of the Small Indian Mongoose (*Herpestes auropunctatus*) (Carnivora: Herpestidae) in Hawai'i¹

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ABSTRACT: Four small Indian mongoose removal plots were monitored on two islands in Hawai'i during a 3-yr period. Both males and females showed natal dispersal in the fall. Males also dispersed during the breeding season. The capture rate of male dispersers decreased greatly between the beginning and the end of the breeding season, possibly indicating high seasonal mortality rates. Ramifications for population management are discussed.

THE SMALL INDIAN MONGOOSE, *Herpestes auropunctatus*, is found across southern Asia from Iraq to Vietnam and south to Malaya and Java (Nellis 1989). It was introduced to four islands in Hawai'i (Hawai'i, O'ahu, Maui, and Moloka'i) in 1883, to control rat populations on sugarcane plantations (Tomich 1986). It also has been introduced to a number of other islands in the Pacific and Indian Oceans, and in the Caribbean and Adriatic Seas (Corbet and Hill 1992). It has been studied almost exclusively in regions of introduction.

This mongoose is a known or suspected nest predator upon eight federally listed endangered or threatened birds in Hawai'i (Stone et al. 1994), and removal trapping and poison bait campaigns against mongooses are often carried out in nesting areas. Mongooses are also an important rabies vector in the Caribbean, where large-scale campaigns are occasionally mounted against them (Nellis and Everard 1983).

The breeding season for this mongoose species lasts from February through August in Hawai'i (Figure 1). All of the islands referred to in Figure 1 are roughly equidistant from the equator (Hawai'i: 19–20° N; St. Croix: 17° 44' N; St. John: 18° 20' N; Viti Levu: 18° S). Grenada, which is at 12° N, has

a 10-month breeding season (Nellis and Everard 1983).

Mean litter size is 2.1, and gestation is 7 weeks (Nellis and Everard 1983). Young are weaned at 6 to 8 weeks of age, but typically stay with the mother until they reach sexual maturity at 4 to 6 months of age (Nellis and Everard 1983).

Home range size for this species has been reported variously as 1.1 to 8.5 ha (Nellis and Everard 1983), 22 to 39 ha (Gorman 1979), and 25 to 100 ha (Stone and Keith 1987). All three studies found broadly overlapping home ranges among individuals, regardless of gender.

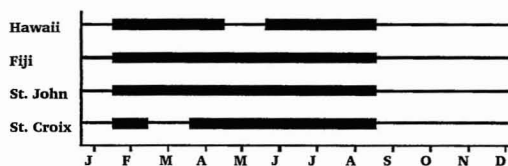
Dispersal has not been previously studied in this species of mongoose, but is known in 2 of the other 28 species of the mongoose family (Herpestidae): the dwarf mongoose (*Helogale parvula*) and the slender-tailed meerkat (*Suricata suricatta*). In dwarf mongooses, dispersal is mainly natal, and, though male-biased, is common among young animals of both genders (Rood 1987). In meerkats, dispersal is mainly breeding dispersal and is common in both genders at all ages, and both genders commonly make temporary exploratory treks that may last up to several months (Doolan and MacDonald 1996). Unfortunately, because of the intricacy of sociality in these two species, their patterns of dispersal may be idiosyncratic and of little value for comparison with small Indian mongooses.

The study reported here investigated sea-

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A) PREGNANT FEMALES



B) LACTATING FEMALES

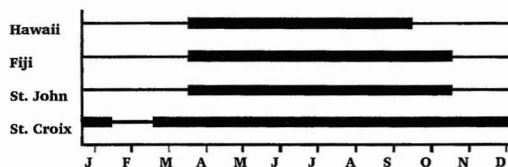


FIGURE 1. Reproductive condition of females in four studies. Hawai'i data ($n = 72$) from Pearson and Baldwin (1953). Fiji data ($n = 801$), adjusted by 6 months for comparison with Northern Hemisphere data, from Gorman (1976). St. John, U.S. Virgin Islands, data ($n = 373$) from Coblenz and Coblenz (1985). St. Croix, U.S. Virgin Islands, data ($n = 321$) from Nellis and Everard (1983); St. Croix bars show all months for which 10% or more of females were in the stated condition.

sonal patterns of dispersal by mongooses on two islands in Hawai'i.

MATERIALS AND METHODS

Data used in this study were gathered incidental to removal trapping of small Indian mongooses in bird refuges on the islands of O'ahu and Hawai'i, 1993–1995, by Animal Damage Control (ADC), an office of the Animal and Plant Health Inspection Service of the U.S. Department of Agriculture. Four sites were studied, all near sea level and all with ponds, marsh, and grassland.

Two of the sites, Honouliuli (15 ha) and Waiawa (10 ha), are units of the Pearl Harbor National Wildlife Refuge in southern O'ahu. The third, Ki'i Pond (66 ha), is a unit of James Campbell National Wildlife Refuge near Kahuku Point at the northern tip of O'ahu. The fourth, 'Aimakapā Pond (10 ha), is part of Koloko-Honokōhau National Historical Park, on the west coast of Hawai'i Island. All four sites were contiguous on two

or more sides with far greater areas of apparently suitable mongoose habitat. Data were used from Honouliuli in 1993, from Waiawa in 1993 through 1995, from Ki'i in 1993 and 1994, and from 'Aimakapā in 1994 and 1995.

Traps consisted of single-door Tomahawk live traps, 18 by 18 by 36 cm. Baits included dog food, fish oil, sardines, commercial scent lures, and table scraps. Traps were shaded under ceramic roof tiles to prevent heat stress of captive animals, and water bottles were provided. All captured animals were killed by asphyxiation.

At each site, traplines were left open with regular checks for a minimum of 15 days per month during a study period of 12, 24, or 36 continuous months per site (average effort, for the 96 site-months: 750 trap-days per site-month, during 26.9 trapping days per month). Data for each capture consisted of site, date, and gender of the captured animal; no data were gathered regarding age.

The three O'ahu sites were removal-trapped before the study periods (with no records), but the initial trapping period at 'Aimakapā was recorded. At this site, more animals were caught in the first 3 months than in any one of the following 3 years, though a steady flow of captures continued. This initial trapping period was excluded from analysis, and it was assumed that all analyzed data represented dispersers that had entered sites from neighboring areas.

To make data comparable, the mean capture rate of traps was equalized among the 8 site-years by scaling downward, and trapping effort was equalized among the 96 site-months, also by scaling downward. Capture data were pooled from the 8 site-years (Figure 2), and the apparent annual patterns in each gender were checked for significance with an analysis of variance (ANOVA) F -test (Kanji 1993).

RESULTS

In the 8 site-years, during 71,974 trap-days, 1248 captures were made. Trap densities at the sites ranged from 0.5 to 3.3 traps per hectare. The sex ratio of captured ani-

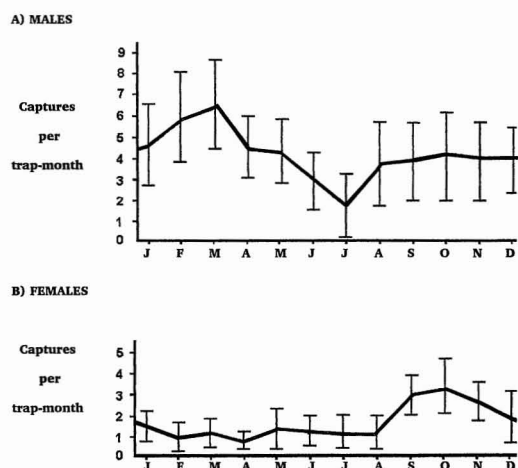


FIGURE 2. Captures per trap per month, in 8 site-years. Error bars represent 95% confidence limits. For treatment of data, see text.

TABLE 1

SOME PUBLISHED SEX RATIOS OF CAPTURED MONGOOSES

LOCATION	MALE : FEMALE RATIO	(n)
Hawai'i Island (Baldwin et al. 1952)	1.87	(225)
Hawai'i Island (Tomich 1969)	1.35	(546)
Hawai'i Island, current study	2.38	(327)
O'ahu, current study	2.44	(921)
Viti Levu, Fiji (Gorman 1979)	1.51	(83)
Puerto Rico (Pimentel 1955)	1.06	(398)
Grenada (Nellis and Everard 1983)	2.80	(1,740)
Trinidad (Nellis and Everard 1983)	1.18	(207)
St. Croix, U.S. Virgin Islands (Nellis and Everard 1983)	1.28	(924)
St. John, U.S. Virgin Islands (Coblentz and Coblentz 1985)	1.34	(1,009)

males was 2.42 males per female overall (2.44 on O'ahu, 2.38 on Hawai'i). Table 1 summarizes sex ratios reported in this and previous studies.

Monthly captures (Figure 2) differed significantly from a normal distribution in each gender (males: $F = 2.76$ [11, 84 df; $P < .005$]; females: $F = 4.9$ [11, 84 df; $P < .001$]). Both

male and female dispersers became more abundant between July and October. Female dispersers became less abundant from October until February and remained at low levels throughout the spring and summer months. The annual peak abundance of male dispersers was in March and decreased by about 70% between March and July.

Data from the 2 site-years at 'Aimakapā, on Hawai'i Island, were compared with data from the 6 site-years at O'ahu sites (Figure 3). A 2 by 12 chi-square analysis was done for each gender and showed no significant differences between the islands (males: $\chi^2 = 14.9$ [$P > 0.1$]; females: $\chi^2 = 11.7$ [$P > 0.1$]).

DISCUSSION

The observed 2.4 male : female ratio may be explained either by a skewing of the population's actual sex ratio, by a trapping bias favoring males, and/or by a greater tendency among males to disperse. A higher percentage of males is known only on Grenada (Table 1), where most of the tallied mongooses came from removal plots similar to those of the current study (Nellis and Everard 1983). The higher relative abundance of males captured on long-term removal plots than in other studies may be due to males showing a greater tendency to disperse than females do.

Previous studies of introduced small Indian mongoose populations in the Caribbean and the Pacific have shown a great deal of variation in parameters of the species's natural history, even among neighboring islands. It is therefore encouraging that the seasonal patterns found in this study are evident on both O'ahu and Hawai'i (Figure 3). The populations on these islands have been isolated from each other for over 110 yr, about as long as introduced populations anywhere in the world.

The autumn increase in both male and female dispersers likely represents emergence of young of the year into the trappable population. Natal dispersal is found in one or both sexes in many small mammal species (Lidicker 1975), and mongooses born in the

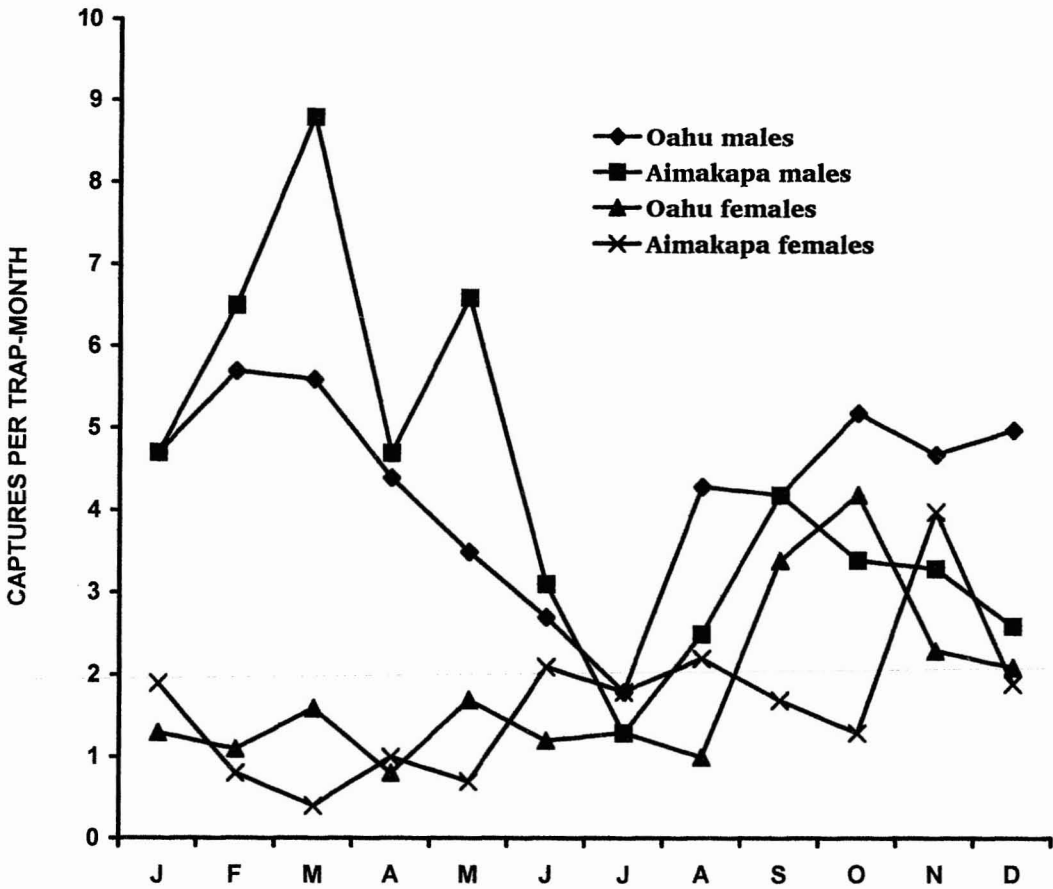


FIGURE 3. Comparison of captures per trap per month on O'ahu and on Hawai'i.

middle of the breeding season attain the age of independence (4 to 6 months) in the months around October. Newly independent individuals of both genders may be dispersing away from saturated natal areas.

The increase in male dispersers between January and March is not likely to be due to further emergence of young, both because of the lateness of season and also the absence of a corresponding increase of female dispersers. It must, then, reflect an increase in the tendency of adult males to disperse, a behavioral change that may be attributable to the onset of the breeding season.

The decline of male dispersers between March and July may be attributed to male mortality and/or to a decreasing tendency for

males to disperse. The possibility of massive male mortality during the breeding season cannot be discounted: a study of survivorship of small Indian mongooses of both genders in the Caribbean found that only 12% survive to age two, and 3% to age three (Nellis and Everard 1983).

The annual pattern of dispersal found in this study suggests that the most effective season for removal effort is September through November, when young females are dispersing. This species of mongoose has small litters, few litters per year, and a long period of maternal investment, which together indicate a low maximum replacement rate. A substantial decrease in female recruitment due to intensive fall trapping

would likely have an important impact on the following year's total births.

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